**BLOOD FLOW MEASUREMENTS IN AN EXPERIMENTAL TIBIAL BONE TRANSPORT MODEL USING TC-99M MDP AND RADIOLABELED RED BLOOD CELL BONE SCANS**

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**Introduction:** The Ilizarov method of distraction osteogenesis is a valuable tool for the treatment of segmental long bone defects. Successful treatment depends on stability of fixation; viability of the vascular supply and marrow cavity; rate, frequency and latency of distraction; and adequacy of consolidation. Several reports have described the induction of a prolonged hypervascular state during and following distraction, however previous reports have focused on angiogenesis or radiotracer emission rather than blood flow itself. Few studies have focused on blood flow and those that have utilized Tc-99m MDP bone scans to measure flow. This technique is thought to be inaccurate in states of elevated flow or with increased osteoblastic activity, both of which conditions are present in distraction osteogenesis. Because an intact vascular supply is necessary for successful union, accurate measurement of blood flow to and around the transported segment may be predictive of clinical outcome and applicable in both management and prognosis. We hypothesize that blood flow may be more accurately measured using radiolabeled red blood cells as compared to Tc-99m MDP bone scans in the hypervascular and osteogenic state induced by the Ilizarov method of distraction osteogenesis. We further hypothesize that segmental bone transport may not exhibit the same increases in blood flow previously reported for distraction osteogenesis.

**Methods:** After approval of the University’s Institutional Review Board, twenty-five New Zealand Rabbits each underwent a proximal tibial segmental corticotomy with monolateral external fixator placement and transport of the bony segment across a diaphyseal defect at a rate of 4mm/week for 5 weeks after a 1-week latency period. Animals were divided into three groups as follows: Group 1 (Tc-99m MDP) was made up of eight rabbits using a 20 mm tibial defect and Tc-99m MDP bone scans to measure blood flow. Group 2 (UltraTag 20) was made up of eight rabbits and utilized radiolabeled red blood cells (UltraTag technique) to measure blood flow. The defect size in this group was also 20 mm. Group 3 (UltraTag 30) contained 9 rabbits using the UltraTag technique, but with a 30 mm diaphyseal defect. Gamma scintigraphy was performed and counts were measured for proximal, middle (transported) and distal tibial segments. Data were expressed as a ratio of counts from the operative to the non-operative limb, thus utilizing each rabbit’s own contralateral limb as control. Scans were performed at 2, 4, 8, 12, 24, 36 and 52 weeks postoperatively. Data from scans up to 12 weeks were used for comparison of results based on technique (group 1 vs. group 2) and to assess the influence of defect size on vascularity using the same technique (group 2 vs. group 3). Longitudinal analysis was continued at 24 and 36 weeks for group 2 and to 52 weeks for four of the nine rabbits in group 3 to investigate the longer-term effects of bone transport on vascularity. A one-way analysis of variance (ANOVA) was done and results were tabulated by comparison of marginal means. FDA approval was not necessary.

**Results:** Group 1 (Tc-99m MDP): Significantly elevated counts over the transported segment of group 1 were measured when compared to the proximal and distal segments at week 2 (p < .01, proximal; p < .05, distal), and the proximal and distal segments at 4, 8 and 12 weeks post-op (p < .01). Significantly greater counts were found in the distal segment when compared to the proximal segment at week 4 (p < .01). Middle and distal segment blood flow peaked at 7.1 and 5.0 times control, respectively, at week 4 while proximal flow decreased with time from a maximum of 3.1 times control (p < .05).

Group 2 (UltraTag 20): No significant changes in blood flow were detected for any segment as a function of time. No differences were detected between segments at any given time period.

Group 3 (UltraTag 30): No significant changes in blood flow were detected for any segment as a function of time. No differences were detected between segments at any given time period.

Comparison between groups: Group 1 showed significantly greater total counts than either group 2 or group 3 (p < .01). Middle segment counts from group 1 were elevated compared to group 2 and group 3 at all time periods up to 12 weeks (p < .01) while comparison of peripheral segments between groups showed elevated flow in the proximal and distal segments of group 1 at weeks 2 and 4 (p < .01) as well as week 8 (p < .05). No differences were found between groups 2 and 3 at any time period for any of the segments. No increases or decreases in flow as a function of time were found using the UltraTag technique at time periods up to 52 weeks.

**Discussion:** The above results show a discrepancy between Tc-99m MDP static phase flow data and UltraTag results. This can be explained by two factors. Tc-99m MDP bone scans are thought to be inaccurate with elevated flow rates due to diffusion limited tracer deposition and preferential osteoblastic uptake in states of net osteogenesis. Both of these conditions are present in distraction osteogenesis and can lead to inaccurate results when using radiolabeled phosphonates to measure blood flow. Because radiolabeled RBCs more directly measure blood flow, this technique is less subject to the above confounds and increased accuracy of measurement can be achieved.

The lack of increased blood flow measured in any of the segments at any time period by the UltraTag technique may be explained by either of two reasons. First, initial reports of flow may have been falsely elevated due to the use of radiolabeled phosphonates for measurement. This coincides with what we have witnessed, as greatest measured increases correlate temporally, with times of greatest osteoblastic activity and spatially, in proximity to greatest osteoblastic activity (namely, the middle segment, as it is bound by two sites of healing rather than just one). Likewise, segmental disruption of the blood supply may impede the induction of the hypervascular response seen in distraction osteogenesis. Within the limits of our study, defect size did not appear to alter vascularity, as increased size did not cause decreased blood flow. When followed longitudinally between 24, 36 and 52 week time periods no decreases in flow were seen with increasing time. These longer-term results, however, are preliminary due to the limited number of data points at time periods greater than 24 weeks (n = 6 rabbits at 36 weeks and n = 4 at 52 weeks). Additional data continues to be acquired on these extended time periods.

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